Coal [*]

Coal is the non-renewable fuel that remains in the greatest abundance. However, there is room for considerable doubt about how much recoverable coal actually remains.

Oil is the non-renewable energy resource which is the primary focus of this report and whose global production rate will almost certainly peak soonest. Nevertheless, the production of all non-renewables will peak eventually. This global production peak will occur at different times for different resources (although it is possible to speak of an overall peak of non-renewable energy resource production, as measured in BTU's). Of all the non-renewable fuels, coal is the most abundant and the one whose production will probably peak the last. The United States is particularly well-placed with regard to coal reserves, with 120 billion tons of oil equivalent (Btoe) as of 2005. This is almost twice the amount of reserves claimed by its closest rival, Russia, with 69 Btoe.[1]

Unfortunately, estimates of the amount of recoverable coal worldwide are subject to a good deal of uncertainty because of the poor quality of reserves data. According to a 2007 report by Germany's Energy Watch Group, "the data quality in general is very poor and the reported data cannot be regarded as a realistic assessment of 'proved recoverable coal reserves," and "there is probably much less coal left to be burnt than most people think."[2] Lending weight to this conclusion were huge revisions in reserve assessments by the World Energy Council for particular countries over the past two decades. Examples, for bituminous and anthracite, include the following:

- In 1991, the reserve estimate for China was reduced from 152,831 million tons (Mt) to 62,200 Mt and then not subsequently revised despite rapidly rising production/consumption.
- In 2003, the reserve estimate for Germany was reduced from 23,000 Mt to 183 Mt, a reduction of 99%. This is because, as the Energy Watch Group wryly noted, "large reserves formerly seen as *proven* have been reassessed as being *speculative*."
- In 1998, the reserve estimate for Poland was reduced from 29,100 Mt to 12,113 Mt. In 2001, it was raised to 20,300 tons. Then, in 2004, it was reduced again, this time to 14,000 Mt.

In general, the trend has been for coal reserve estimates to be downgraded significantly rather than upgraded significantly, although there have been exceptions. One of the most notable exceptions was an upgrade in the reserve estimate for India in 1990 from 12,610 Mt to 60,098 Mt, and then in four additional steps through 2004 to 90,085 Mt.[3] By 2007, however, the World Energy Council was reporting a reserve estimate for Indian bituminous of only 52,240 Mt[4] after India shifted from reporting "coal in place" to reporting "recoverable coal."

[*] *Discussion Sheet Prepared by Peak Oil Task Force Member, Gary Charbonneau.*

The World Energy Council's estimate of total recoverable coal in the world as of the end of 2005 was 847,388 Mt (430,896 Mt of anthracite and bituminous, 266,837 Mt of sub-bituminous and 149,744 Mt of lignite).[5] Prof. David Rutledge of Caltech believes that the actual amount is considerably lower: 662,000 Mt.[6]

Statements to the effect that "We have hundreds of years of coal remaining" are suspect and apt to be rather misleading. We should be very careful about taking them at face value.

The amount of coal remaining is often expressed in terms of a reserve-to-production (R/P) ratio – that is, the estimate amount of remaining reserves, divided by the current year's production. Such estimates can be made for the entire world, for a single nation, or for part of a nation. For example, according to the Indiana Geological Survey, Indiana has about 17.54 billion tons of "available coal resources" remaining,[7] where "available coal resources" is defined as:

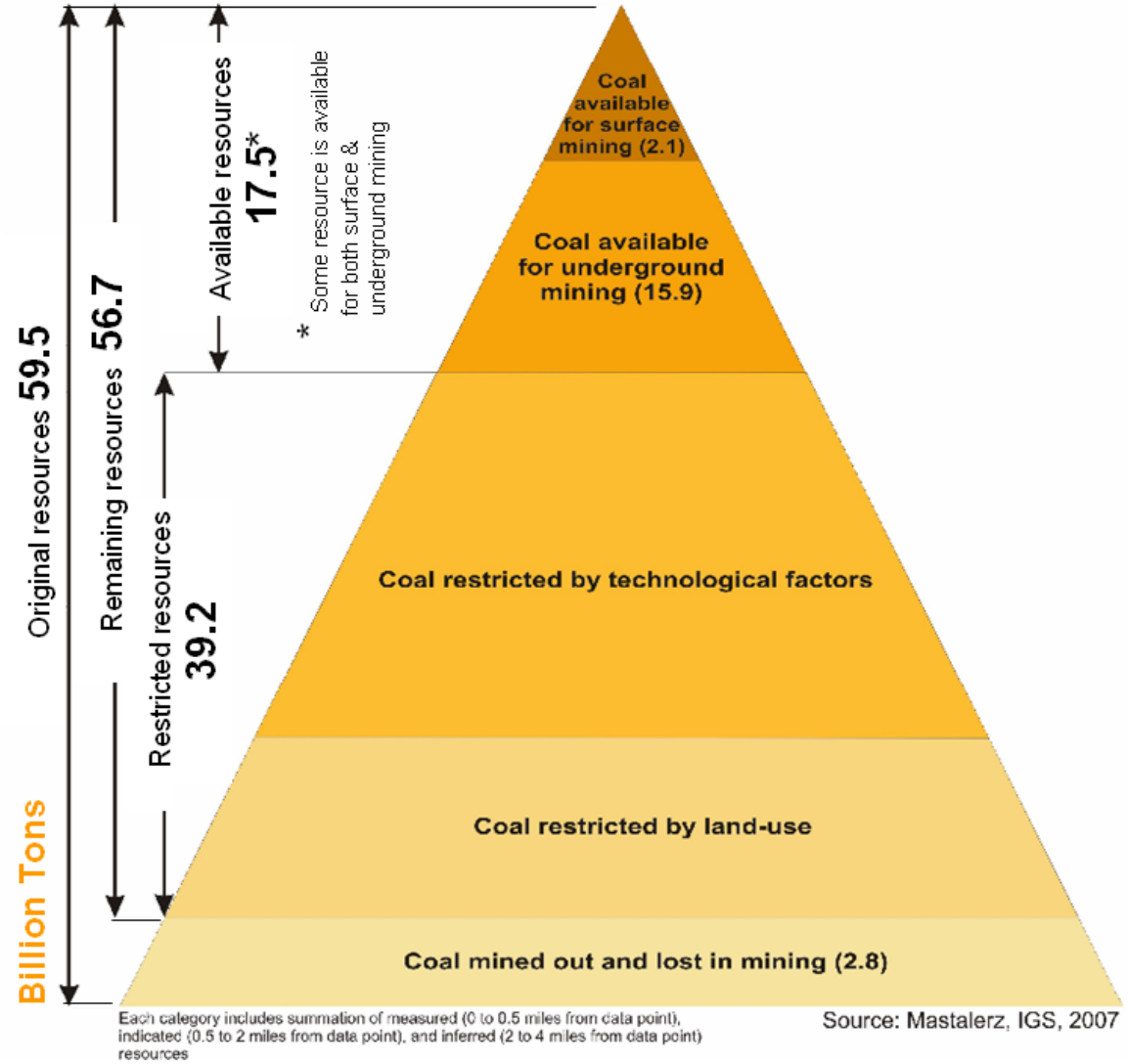
Original coal resources, minus coal mined and lost in mining, minus coal restricted by land use, minus coal restricted by technological factors.[8]

The Indiana Geological Survey states, "Taking into account the current level of coal production in Indiana (approximately 30 million [mln] short tons a year), 17.54 billion tons of coal could last about 585 years."[9]

Unfortunately, stated coal R/P ratios are subject to wild fluctuations, depending on revisions in estimates on the amount of recoverable coal remaining, and changes in the amount of coal currently being produced. In general, R/P ratios for coal have tended to be adjusted downward rather than upward (in part because, as noted above, there has been a tendency to adjust reserve estimates downward). For example, the earliest R/P ratio estimate for the United States, made in the 1920's, claimed that the U.S. had enough coal to last for over 4000 years,[10] but this calculation was badly flawed, partly because of an exaggerated estimate on the amount of recoverable coal in the country. More recent R/P ratio estimates claim that the U.S. has enough coal to last a little over 200 years.

Let us consider the statement by the Indiana Geological Survey that Indiana coal "could last about 585 years" – a figure reported in the press and taken at face value by our state government -- and examine it carefully. The first thing to note is that it is based on the conclusion by the IGS that Indiana has approximately 17.5 billion tons of "available coal resources," as shown in Fig. 1:

Fig. 1. Indiana Available Coal Resources, According to the Indiana Geological Survey.



As this figure indicates, the IGS believes that ~88% of Indiana's available coal is recoverable by underground mining, while ~12% is recoverable by surface mining (a small proportion is recoverable by either technique). In 2002, almost 78% of Indiana's coal production came from surface mining, and a little over 22% from underground mining,[11] suggesting that full recovery of Indiana's available coal would require a significant switch from less labor-intensive surface mining to more labor-intensive underground mining.

There is a major discrepancy between the 17.5 billion tons of coal reported by the Indiana Geological Survey and the figure currently being reported by the federal Energy Information Administration (EIA). The EIA says that Indiana has a "demonstrated reserve base" of 9.379 billion tons, and "estimated recoverable reserves" of 4.001 billion tons.[12] Clearly, if the EIA figure is correct, then Indiana's coal would not last 585 years

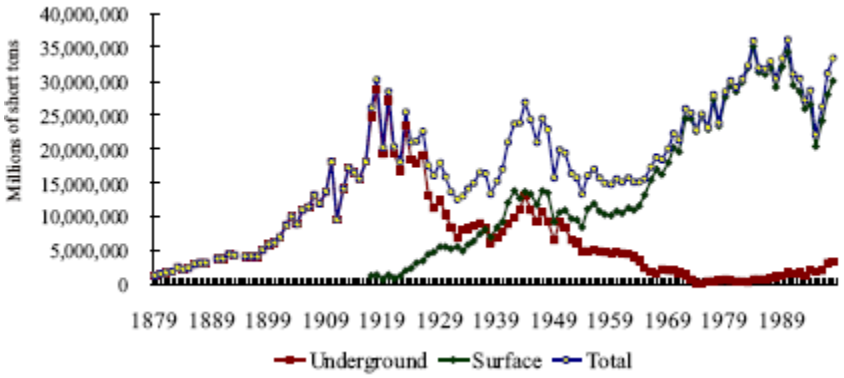
at the current production rate, but considerably less – using a figure of 4.001 billion tons of recoverable reserves and a production rate of 30 million tons per year, the R/P ratio would point to about 134 years of coal remaining, not 585 years.

When queried about the discrepancy between the Indiana Geological Survey and Energy Information Agency figures regarding Indiana coal reserves, George Warholic of the EIA attributed it to "EIA's current inability to incorporate updated reserve data into [its] existing database" because of lack of funding – an admission that the data provided by the federal agency charged with producing the "official energy statistics from the U.S. government" are perhaps somewhat questionable.

According to Warholic, there was another likely explanation as well: "differences in recoverable reserves definitions." The statement that Indiana has 585 years of coal left at the current production rate comes from a 2004 report by the Indiana Geological Survey entitled *Characterization of Indiana's Coal Resource: Availability of the Reserves, Physical and Chemical Properties of the Coal, and Present and Potential Uses.* Warholic indicated familiarity with this document, and said, "The report does not seem to provide any recovery factors, i.e., the amount of coal recovered from mining the available resources. For Indiana coal production, EIA uses recovery ratios of 41.4 percent for underground and 58.5 percent for surface mines. These recovery factors would substantially deflate the reserve estimate of 17 billion tons."[13] Indeed they would. Assuming that Indiana has 2.0 billion tons of coal "available" for surface mining and 15.5 billion tons "available" for underground mining, then the total amount of coal actually "recoverable" would be, according to the EIA's recovery ratios, 1.17 billion tons from surface mining and 6.417 billion tons from underground mining, or 7.587 billion tons. This is considerably more than the 4.001 billion tons according to the EIA's "official" figures, but considerably less than the 17.5 billion tons according to the Indiana Geological Survey and would point to an R/P ratio that would imply that Indiana has about 254 years of coal left, not 585 years.

In addition to considering the "reserves" numerator in the R/P ratio somewhat uncertain, we must also note that the "production" divisor is subject to change from year to year. Thus, if the production rate goes down, the recoverable coal will last longer, while if the production rate goes up, the recoverable coal will not last as long. Coal production in Indiana has been subject to considerable variation over the past century, rising to one peak during World War I, then falling as production shifted to non-union mines in other states and because of the Great Depression, then rising to a second peak during World War II, then falling into another trough during the 1950's, and then rising once again to a new and even higher peak, or series of peaks, as indicated in Fig. 2:

Fig. 2: Indiana Coal Production History

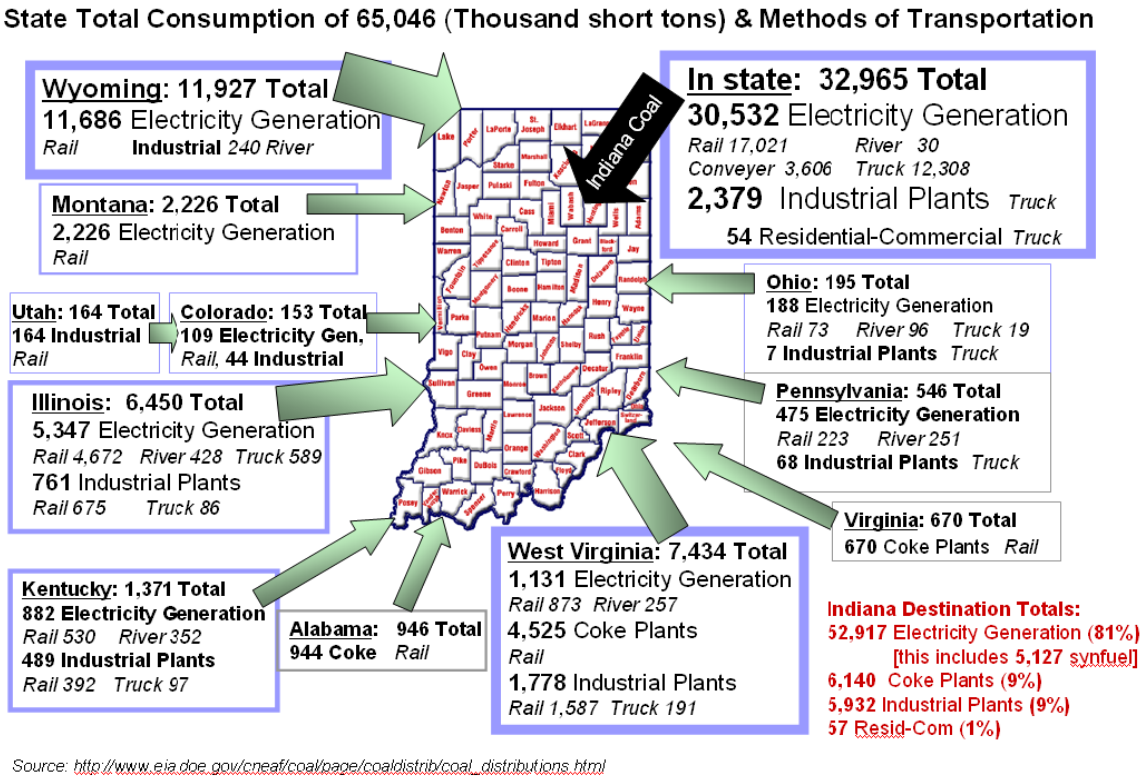


Source: Maria Mastalerz et al., Characterization of Indiana's Coal Resource, 2004, p. 76

Current production levels, after taking a brief dip for an unknown reason, are again near their all-time high.

The statement that "Indiana has 585 of coal remaining at the current rate of production" is apt to be particularly misleading without consideration of the current rate of *consumption*. The fact is that Indiana currently consumes about twice as much coal as it produces. Most of the coal imported into Indiana comes from the states of Wyoming, West Virginia, and Illinois, as indicated in Fig. 3:

Fig. 3. Sources and Uses of Coal in Indiana.



Source: http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/coal_distributions.html

If Indiana were required to be self-sufficient in coal, it would (barring a halving of consumption) have to double its coal production, which means that current coal reserves would last only half as long as they would at the state's present production rate.

It is very difficult to predict how long the available coal will last, whether globally, nationally, or at the state level.

Although the prevailing sense is that there is "plenty" of coal left, the Energy Watch Group warns that global production could peak as early as 2020-2025. The EWG is particularly concerned about the supply situation in China, where consumption has been rising especially rapidly over the last decade. It believes that "China will reach maximum production within the next 5-15 years, probably around 2015…. The steep rise in production of the past few years must be followed by a steep decline after 2020."[14] It also believes that "the strongly rising production of China will have a substantial influence on the peak of world coal production. Once China cannot increase its production any more global coal production will peak."[15]

Startling as is the conclusion that global coal production will peak by 2020-2025, even more startling is the Energy Watch Group's conclusion that U.S. coal production may *already* have peaked: "Though total production volumes are still increasing due to the expanding production of sub-bituminous coal in Wyoming, coal production in terms of energy had already peaked in 1998 at 598 Mtoe [million tons of oil equivalent] compared to 576 Mtoe in 2005."[16] On the other hand, the EWG notes that the U.S. still retains, if the official figures are to be believed, substantial remaining coal reserves in several other states. Its argument that "it is not probable that the huge reserves in Montana, Illinois, Western Kentucky and Ohio will be converted into production"[17] is not entirely convincing. Should global coal production peak early and leave the world hungry for hydrocarbons, it seems unlikely that these reserves would remain untapped. Although the U.S. has ceased to be a net coal exporter and now imports a small amount of coal, it is possible to imagine a scenario in which the U.S., the nation with the world's most extensive reserves, once again becomes a major exporter. For the same reason, although Indiana currently exports only a small amount of coal to power plants in neighboring states, it is possible to imagine a scenario in which Indiana participates in an export boom and significantly increases its production. Should that happen, there would be an increase in the size of the production divisor in the state's R/P ratio, reducing the "number of years" that the state's coal would last. This would especially be the case if demand for coal-generated electricity increases significantly because peak oil causes the world to turn to electric vehicles or coal-to-liquids (CTL) production. On the other hand, the increase in demand could be moderated by rapid penetration of wind- or solar-generated electricity into the marketplace.

[1]Energy Watch Group, *Coal: Resources and Future Production* (http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf), Mar. 2007, p. 6.
[2] *Ibid.*, p. 24 and p. 4.
[3] *Ibid.*, p. 26.
[4] World Energy Council, *2007 Survey of Energy Resources* (http://www.worldenergy.org/documents/ser2007_final_online_version_1.pdf), p. 22.
[5] *Ibid.*, p. 23.
[6] David Rutledge, *Hubbert's Peak, the Coal Question, and Climate Change*, Watson Lecture at California Institute of Technology, 10/17/2007, http://today.caltech.edu/theater/item?story%5fid=24502
[7] Maria Mastalerz *et al.*, *Characterization of Indiana's Coal Resource: Availability of the Reserves, Physical and Chemical Properties of the Coal, and Present and Potential Uses*, Open-File Study 04-02, Indiana Geological Survey, July 2004, Table 15, "Summary of available and restricted coal resources for main economic coal beds in Indiana."
[8] *Ibid.*, p 16.
[9] *Ibid.*, pp. 23-24.
[10] Rutledge, *Hubbert's Peak*….
[11] Mastalerz *et al.*, p. 14.
[12] Energy Information Administration, "Recoverable Coal Reserves at Producing Mines, Estimated Recoverable Reserves, and Demonstrated Reserve Base by Mining Method," Report no. DOE/EIA 0584 (2007), released Sept. 2008 (http://www.eia.doe.gov/cneaf/coal/page/acr/table15.html)
[13] Personal communication from George Warholic, Energy Information Administration, Dec. 9, 2008.
[14] Energy Watch Group, *Coal*…, p.27.
[15] *Ibid.*, p. 15.
[16] *Loc cit.*
[17] *Ibid.*, p. 38.